NASA SP-238

APOLLO 11

Mission Report

PREPARED BY
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NASA MANNED SPACECRAFT CENTER

Scientific and Technical Information Office 1971
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C.

12. BIOMEDICAL EVALUATION

This section is a summary of the Apollo 11 quarantine procedures and medical findings, based upon a preliminary analysis of biomedical data. More comprehensive evaluations will be published in separate medical reports.

The three crewmen accumulated 585 man-hours of space flight experience during the lunar landing mission, including 2 hours 14 minutes and 1 hour 42 minutes on the lunar surface for the Commander and the Lunar Module Pilot, respectively.

The crew's health and performance were excellent throughout the flight and the 18-day postflight quarantine period. No significant physiological changes were observed after this mission, as has been the case on all previous missions, and no effects attributable to lunar surface exposure have been observed.

Bioinstrumentation and Physiological Data

The biomedical data were of very good quality. Only two minor problems occurred, both late in the flight. Data from the Command Module Pilot's impedance pneumogram became unreadable, and the Lunar Module Pilot's electrocardiogram signal degraded because of drying of the electrode paste under the sensors. The Lunar Module Pilot replaced the electrocardiogram leads in his bioinstrumentation harness with the spare set from the medical kit, and proper readings were restored. No attempt was made to correct the Command Module Pilot's respiration signal, because of entry preparations. Physiological parameters were always within expected ranges, and sleep data were obtained on all three crewmen during most of the mission.

The average heart rates during the entire mission were 71, 60, and 67 beats/min for the Commander, Command Module Pilot, and Lunar Module Pilot, respectively. During the powered descent and ascent phases, the only data planned to be available were the Commander's heart rates, which ranged from 100 to 150 beats/min during descent and from 68 to 120 beats/min during ascent, as shown in figures 12-1 and 12-2, respectively.

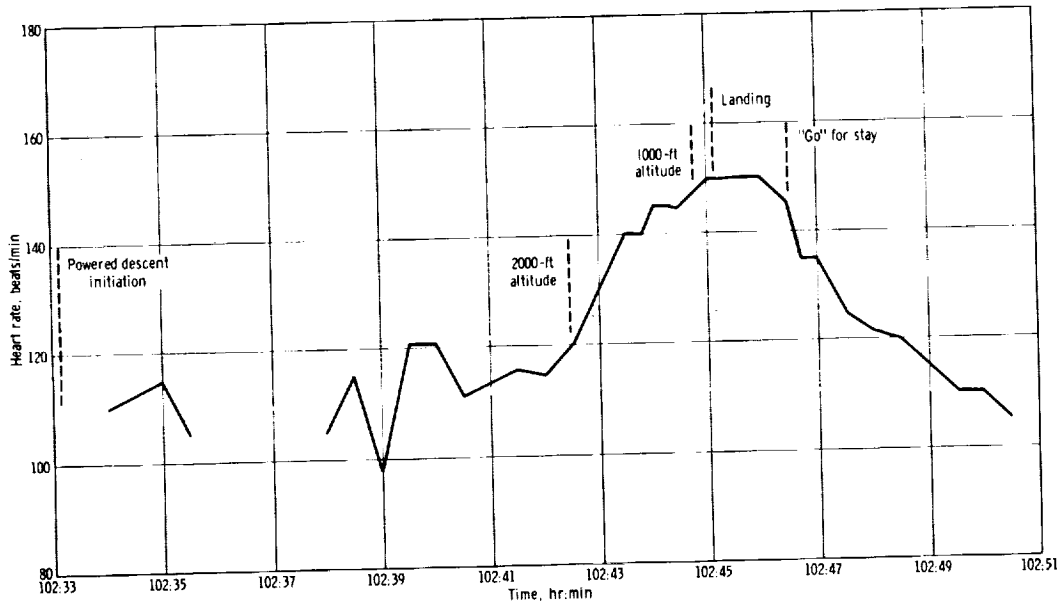


Figure 12-1.- Heart rates of the Commander during lunar descent.

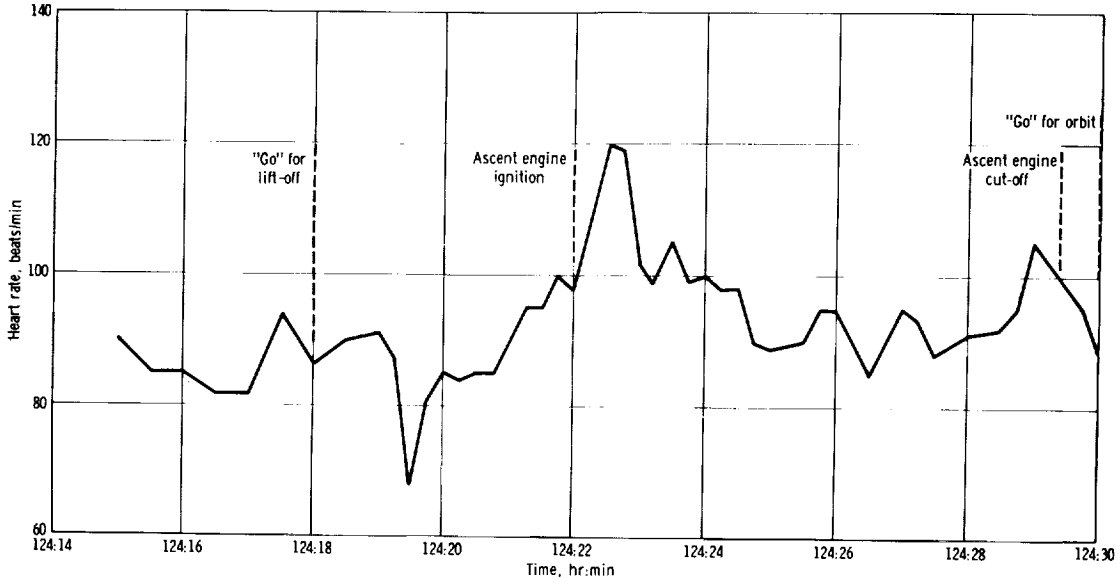
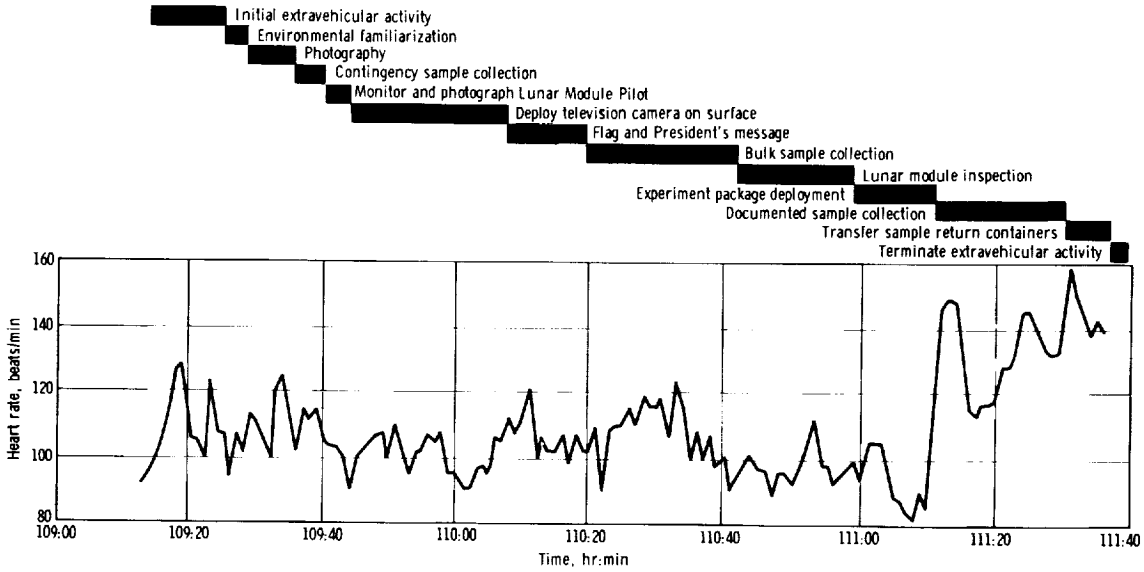


Figure 12-2.- Heart rates of the Commander during ascent.

Plots of heart rates during lunar surface exploration are shown in figure 12-3. The average heart rates were 110 beats/min for the Commander and 88 beats/min for the Lunar Module Pilot. The increase in the Commander's heart rate during the last phases of this activity is indicative of an increased workload and body heat storage. The metabolic production of each crewman during the extravehicular activity is reported in "Extravehicular Activity" in this section.



(a) Commander.

Figure 12-3.- Heart rates during extravehicular activities.

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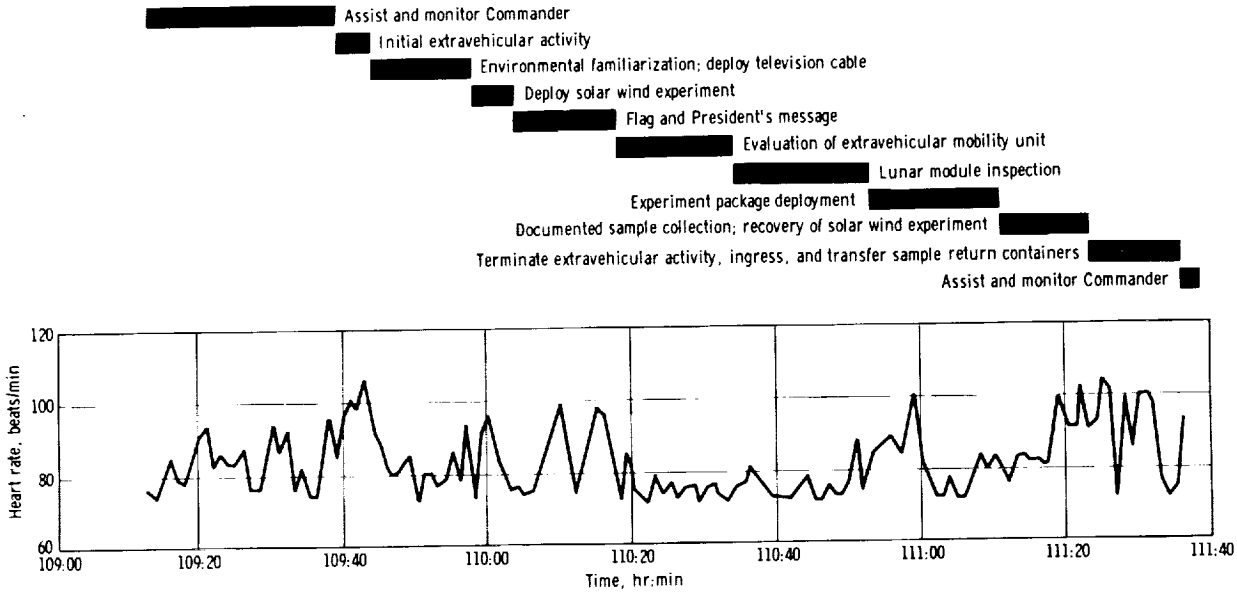

(b) Lunar Module Pilot.

Figure 12-3.- Concluded.

Medical Observations

Adaptation to weightlessness.- The Commander reported that he felt less zero-g effects, such as fullness of the head, than he had experienced on his previous flight. All three crewmen commented that the lack of a gravitational pull caused a puffiness underneath their eyes, and this condition caused them to squint somewhat. However, none felt ill effects associated with this puffiness. In donning and doffing the suits, the crewmen had no feeling of tumbling or the disorientation which has been described by the Apollo 9 crew.

During the first 2 days of the flight, the Command Module Pilot reported that half a meal was more than enough to satisfy his hunger, but his appetite subsequently returned.

Medications.- The Commander and the Lunar Module Pilot each took one Lomotil tablet prior to the sleep period to retard bowel movements before the lunar module activity. The Commander and Lunar Module Pilot each carried extra Lomotil tablets into the lunar module, but did not take them. At 4 hours before entry and again after splashdown, the three crewmen each took antinausea tablets containing 0.3 milligram of Hyoscine and 5.0 milligrams of Dexedrine. The crewmen also took aspirin tablets, but the number of tablets per individual was not recorded. The Lunar Module Pilot recalled that he had taken two aspirin tablets almost every night to aid his sleep.

Sleep.- It is interesting to note that the crewmen's subjective estimates of amount of sleep were less than those based upon telemetered biomedical data, as shown in table 12-I. By either count, the crewmen slept well in the command module. The simultaneous sleep periods during the translunar coast were carefully monitored, and the crew arrived on the lunar surface well rested. Therefore, it was not necessary to wait until after the first planned 4-hour sleep period before conducting the extravehicular activity.

The crewmen did not sleep well in the lunar module following the lunar surface activity. (See "Lunar Surface Operations" in section 4.) However, the crewmen slept well during all three transearth sleep periods.

TABLE 12-I.- ESTIMATED SLEEP DURATIONS

Time of crew report, hr:min	Estimated amount of sleep, hr:min					
	Telemetry			Crew report		
	Commander	Command Module Pilot	Lunar Module Pilot	Commander	Command Module Pilot	Lunar Module Pilot
23:00	10:25	10:10	8:30	7:00	7:00	5:30
48:15	9:40	10:10	9:15	8:00	9:00	8:00
71:24	9:35	(a)	9:20	7:30	7:30	6:30
95:25	6:30	6:30	5:30	6:30	6:30	5:30
Total	36:10	--	32:35	29:00	30:00	25:30

[a]No data available.

Radiation.- The personal radiation dosimeters were read at approximately 12-hour intervals, as planned. The total integrated, but uncorrected, doses were 0.25, 0.26, and 0.28 rad for the Commander, Command Module Pilot, and Lunar Module Pilot, respectively. The Van Allen belt dosimeter indicated total integrated doses of 0.11 rad for the skin reading and 0.08 rad for the depth reading during the entire mission. Thus, the total dose for each crewman is estimated to have been less than 0.2 rad, which is well below the medically significant level. Results of the radiochemical assays of feces and urine and an analysis of the onboard nuclear emulsion dosimeters will be presented in a separate medical report.

The crewmen were examined with a total body gamma-radioactivity counter on August 10, 1969, after release from quarantine. No induced radioactivity was detected, based on critical measurements and an integration of the total-body gamma spectrum. The examination for natural radioactivity revealed the levels of potassium-40 and cesium-137 to be within the normal range.

Inflight exercise.- The planned exercise program included isometric and isotonic exercises and the use of an exerciser. As in previous Apollo missions, a calibrated exercise program was not planned. The inflight exerciser was used primarily for crew relaxation. During transearth coast, the Lunar Module Pilot exercised vigorously for two 10-minute periods. His heart rate reached 170 and 177 beats/min, and the partial pressure of carbon dioxide increased approximately 0.6 mm Hg during these periods. The heart rates and the carbon dioxide readings rapidly returned to normal levels when exercise ceased.

Drug packaging.- Several problems concerning drug packaging developed during the flight. All the medications in tablet and capsule form were packaged in individually sealed plastic or foil containers. When the medical kit was unstowed in the command module, the packages were blown up like balloons because the air had not been sufficiently

evacuated during packaging. This ballooning increased the volume of the medical-kit contents after the kit was opened and thus prevented restowage until a flap was cut away from the kit. Venting of each of the plastic or foil containers will be accomplished for future flights and should prevent this problem from recurring. The Afrin nasal spray bubbled out when the cap was removed and was therefore unusable. The use of cotton in the spray bottle is expected to resolve this problem on future flights.

Water.- The eight inflight chlorinations of the command module water system were accomplished normally and essentially as scheduled. Analysis of the potable water samples obtained approximately 30 hours after the last inflight chlorination showed a free-chlorine residual of 0.8 milligram from the drinking dispenser port and 0.05 milligram from the hot-water port. The iodine level in the lunar module tanks, based on preflight sampling, was adequate for bacterial protection throughout the flight.

Chemical and microbiological analyses of the preflight water samples for both spacecraft showed no significant contaminants. Tests for coliform and anaerobic bacteria, as well as for yeasts and molds, were negative during the postflight water analysis, which was delayed because of quarantine restrictions.

A new gas/water separator was used with satisfactory results. The palatability of the drinking water was greatly improved over that of previous flights because of the absence of gas bubbles, which can cause gastrointestinal discomfort.

Food.- The food supply for the command module included rehydratable foods and beverages, wet-packed foods, foods contained in spoon-bowl packages, dried fruit, and bread. The new food items for this mission were candy sticks and jellied fruit candy; ham, chicken, and tuna salad spreads packaged in lightweight aluminum, easy-open cans; and cheddar cheese spread and frankfurters packaged in flexible foil as wet-packed foods. A new pantry-type food system allowed real-time selection of food items based upon individual preference and appetite. Four meal periods on the lunar surface were scheduled, and extra optional items were included with the normal meal packages.

Prior to flight, each crewman evaluated the available food items and selected his flight menus. The menus provided approximately 2300 kilocalories per man per day and included 1 gram of calcium, 0.5 gram of phosphorus, and 80 grams of protein. The crewmen were well satisfied with the quality and variety of the flight foods. They reported that their food intake met their appetite and energy requirements.

The preparation and eating of sandwiches presented no problems. The only criticisms of the food system were that the coffee was not particularly good and that the fruit-flavored beverages tasted too sweet. The new gas/water separator was effective in reducing the amount of gas in the water and greatly improved the taste of the rehydratable foods.

Extravehicular Activity

The integrated rates of Btu production and the accumulated Btu production during the intervals of planned activities are listed in table 12-II. The actual average metabolic production per hour was estimated to be 900 Btu for the Commander and 1200 Btu for the Lunar Module Pilot. These values are less than the preflight estimates of 1350 and 1275 Btu for the respective crewmen.

TABLE 12-II.- METABOLIC RATES DURING LUNAR SURFACE EXPLORATION[a]

Event	Starting time, hr:min	Duration, min	Rate, Btu/hr	Estimated work, Btu	Cumulative work, Btu
Commander					
Initial extravehicular activity	109:13	11	900	165	165
Environmental familiarization	109:24	3	800	40	205
Photography	109:27	7	875	102	307
Contingency sample collection	109:34	5	675	56	363
Monitoring and photography of Lunar Module Pilot	109:39	4	850	57	420
Television camera deployment on surface	109:43	23	750	288	708
U.S. flag deployment and President's message	110:06	12	825	165	873
Bulk sample collection	110:18	23	850	326	1199
Lunar module inspection	110:41	18	675	203	1402
Experiment package deployment	110:59	12	775	155	1557
Documented sample collection	111:11	19	1250	396	1953
Transfer of sample return containers	111:30	7	1450	169	2122
Extravehicular activity termination	111:37	2	1400	48	2170
TOTAL		146			2170
Lunar Module Pilot					
Assistance and monitoring of Commander	109:13	26	1200	520	520
Initial extravehicular activity	109:39	5	1950	163	683
Environmental familiarization; television cable deployment	109:44	14	1200	280	963
Solar wind experiment deployment	109:58	6	1275	128	1091
U.S. flag deployment and President's message	110:04	14	1350	315	1406
Evaluation of extravehicular mobility unit	110:18	16	850	227	1633
Lunar module inspection	110:34	19	875	277	1910
Experiment package deployment	110:53	18	1200	360	2270
Documented sample collection; recovery of solar wind experiment	111:11	12	1450	290	2560
Extravehicular activity termination, ingress, and transfer of sample return containers	111:23	14	1650	385	2945
Assistance and monitoring of Commander	111:37	2	1100	37	2982
TOTAL		146			2982

[a]Values are from the integration of three independent determinations of metabolic rate based on heart rate, decay of oxygen supply pressure, and liquid cooling garment thermodynamics.

Physical Examinations

Comprehensive medical evaluations were conducted on each crewman at 29, 15, and 5 days prior to the day of launch. Brief physical examinations were then conducted each day until launch.

The postflight medical evaluation included the following: microbiology studies, blood studies, physical examinations, orthostatic tolerance tests, exercise response tests, and chest X-rays.

The recovery-day examination revealed that all three crewmen were in good health and appeared to be well rested. They showed no fever and had lost no more than the expected amount of body weight. Each crewman had taken antimotion sickness medication 4 hours prior to entry and again after landing, and no seasickness or adverse symptoms were experienced.

Data from chest X-rays and electrocardiograms were within normal limits. The only positive findings were small papules beneath the axillary sensors on both the Commander and the Lunar Module Pilot. The Commander had a mild serous otitis media of the right ear, but could clear his ears without difficulty. No treatment was necessary.

The orthostatic tolerance test showed significant increases in the immediate postflight heart-rate responses, but these increases were less than the changes seen in previous Apollo crewmembers. In spite of this apparent improvement, the return to preflight values was slower than had been observed for previous Apollo crewmembers. The reasons for this slower recovery are not clear at this time, but in general, these crewmembers exhibited less decrement in oxygen consumption and work performed than was observed in exercise response tests after previous Apollo flights.

Followup evaluations were conducted daily during the quarantine period in the Lunar Receiving Laboratory, and the immunohematology and microbiology analyses revealed no changes attributable to exposure to the lunar surface material.

Lunar Contamination and Quarantine

The two fundamental responsibilities of the lunar sample program were to preserve the integrity of the returned lunar samples in the original or near-original state and to make practical provisions to protect the earth from possible contamination by lunar substances that might be infectious, toxic, or otherwise harmful to man, animals, or plants.

The Public Laws and Federal Regulations concerning contamination control for lunar-sample-return missions are described in reference 7. An interagency agreement between the National Aeronautics and Space Administration; the Department of Agriculture; the Department of Health, Education, and Welfare; the Department of the Interior; and the National Academy of Sciences (ref. 8) confirmed the existing arrangements for the protection of the earth and defined the Interagency Committee on Back Contamination. The quarantine schemes for manned lunar missions were established by the Interagency Committee on Back Contamination (ref. 9).

The planned 21-day crew quarantine represented the period required in order to preclude the development of infectious disease conditions that could generate volatile epidemic events. In addition, early signs of latent infectious diseases with longer incubation periods would probably be detected through extensive medical and clinical pathological examinations. However, to provide additional assurance that no infectious

disease of lunar origin is present in the Apollo 11 crewmembers, an extensive epidemiological program will continue for 1 year after their release from quarantine.

Lunar exposure.- Although each crewman attempted to clean himself and the equipment before ingress, a fairly large amount of dust and grains of lunar surface material was brought into the cabin. When the crewmen removed their helmets, they noticed a distinct, pungent odor emanating from the lunar material. The texture of the dust was like powdered graphite, and both crewmen were very dirty after they removed their helmets, overshoes, and gloves. The crewmen cleaned their hands and faces with tissues and with towels that had been soaked in hot water. The Commander removed his liquid cooling garment in order to clean his body. One grain of material got into the Commander's eye, but was easily removed and caused no problem. The dustlike material could not be removed completely from beneath the crewmen's fingernails.

The cabin cleaning procedure involved the use of a vacuum-brush device and positive air pressure from the suit supply hoses to blow remote particles into the atmosphere for collection in the lithium hydroxide filters in the environmental control system.

The concern that particles remaining in the lunar module would float in the cabin atmosphere at zero-g after ascent caused the crew to remain helmeted to prevent contamination of the eyes and respiratory system. However, floating particles were not a problem. The cabin and equipment were further cleaned with the vacuum brush. The equipment from the surface and the pressure garment assemblies were placed in bags for transfer to the command module. Before transfer to the command module, the spacecraft systems were configured to cause a positive gas flow from the command module through the hatch dump/relief valve in the lunar module.

During the return to earth, the interior of the command module was cleaned at 24-hour intervals by using the vacuum brush and towels. In addition, the circulation of the cabin atmosphere through the lithium hydroxide filters continued to remove traces of particulate material.

Recovery procedures.- The recovery procedures were successfully conducted with no compromises of the planned quarantine techniques. The times of the major postlanding events are listed in "Recovery Operations" in section 13.

After the command module was uprighted, four biological isolation garments and the decontamination gear were lowered to one of two liferafts. One of the four swimmers donned a biological isolation garment. The second liferaft was then moved to the spacecraft. The protected swimmer retired with the second liferaft to the original upwind position. The hatch was opened, the crew's biological isolation garments were inserted into the command module, and the hatch was closed.

After donning the biological isolation garments, the crew egressed. The protected swimmer sprayed the upper deck and hatch areas with Betadine, a water-soluble iodine solution, as planned in the quarantine procedure. After the four men and the liferaft were wiped with a solution of sodium hypochlorite, the three swimmers returned to the vicinity of the spacecraft to stand by during the helicopter pickup of the flightcrew.

The crewmen were brought up into the helicopter without incident and remained in the aft compartment. As expected, a moderate amount of water was present on the floor after retrieval, and the water was wiped up with towels. The helicopter crewmen were also protected from possible contamination.

The helicopter was moved to the Mobile Quarantine Facility on the lower deck of the recovery vessel. The crewmen walked across the deck, entered the Mobile Quarantine Facility, and removed their biological isolation garments. The descent steps and the deck

area between the helicopter and the Mobile Quarantine Facility were sprayed with glutaraldehyde solution, which was mopped up after a 30-minute contact time.

After the crewmen had been picked up, the protected swimmer scrubbed the upper deck around the postlanding vents, the hatch area, and the flotation collar near the hatch with Betadine. The remaining Betadine was emptied into the bottom of the recovery raft. The swimmer removed his biological isolation garment and placed it in the Betadine in the liferaft. The disinfectant sprayers were dismantled and sunk. After a 30-minute contact time, the liferaft and remaining equipment were sunk.

Following egress of the flightcrew and a recovery surgeon from the helicopter, the hatch of the helicopter was closed and the vehicle was towed to the flight deck for decontamination with formaldehyde.

The crew became uncomfortably warm while they were enclosed in the biological isolation garments in the environment (90° F) of the helicopter cabin. On two of the garments, the visor fogged up because of the improper fit of the nose and mouth cup. To alleviate this discomfort on future missions, consideration is being given to (1) replacing the present biological isolation garment with a lightweight coverall, similar to whiteroom clothing, with respirator mask, cap, gloves, and booties and (2) using a liquid cooling garment under the biological isolation garment.

The command module was taken aboard the U.S.S. Hornet approximately 3 hours after landing and was attached to the Mobile Quarantine Facility through a flexible tunnel. The removal of lunar surface samples, film, data tape, and medical samples went well, with one exception. Two of the medical sample containers leaked within the inner biological isolation container. Corrective measures were promptly executed, and the quarantine procedure was not violated.

Transfer of the Mobile Quarantine Facility from the recovery ship to a C-141 aircraft and from the aircraft to the Lunar Receiving Laboratory at the NASA Manned Spacecraft Center was accomplished without any question of a quarantine violation. The transfer of the lunar surface samples and the command module into the Lunar Receiving Laboratory was also accomplished as planned.

Quarantine.- A total of 20 persons on the medical support teams were exposed, directly or indirectly, to lunar material for periods ranging from 5 to 18 days. Daily medical observations and periodic laboratory examinations showed no signs or symptoms of infectious disease related to lunar exposure.

No microbial growth was observed from the prime lunar samples after 156 hours of incubation on all types of differential media. No micro-organisms which could be attributed to an extraterrestrial source were recovered from the crewmen or the spacecraft.

None of the 24 mice injected intraperitoneally with lunar material showed visible shock reaction following injection, and all remained alive and healthy during the first 10 days of a 50-day toxicity test. During the first 7 days of testing of the prime lunar samples in germ-free mice, all findings were consistent with the decision to release the crew from quarantine.

Samples from the crewmen were injected into tissue cultures, suckling mice, mycoplasma media, and 6- and 10-day-old embryonated eggs. There was no evidence of viral replication in any of the host systems at the end of 2 weeks. During the first 8 days of testing the lunar material, all findings were compatible with crew release from quarantine.

No significant trends were noted in any biochemical, immunological, or hematological parameters in either the flightcrew or the medical support personnel.

The personnel in quarantine and in the Crew Reception Area of the Lunar Receiving Laboratory were approved for release from quarantine on August 10, 1969. Following decontamination with formaldehyde, the interior of the command module and the ground servicing equipment utilized in the decontamination procedures were approved for release from quarantine on August 10, 1969. The samples of lunar material and other items stored in the biological isolation containers in the Lunar Receiving Laboratory were released to principal scientific investigators in September 1969.